

# **The Stevens Integrated Maritime Surveillance and Forecast System**

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## **LONG-TERM GOALS**

The long-term goal of the project is to develop an advanced, integrated system of oceanographic, meteorological, and vessel surveillance sensors and littoral ocean forecasting models to allow for the real-time assessment of ocean, weather, environmental, and vessel traffic conditions throughout the New York Harbor region, and forecast of conditions in the near and long-term and under specific threat scenarios. In the long-term, the system will be enhanced by modern data assimilation techniques and model-controlled ocean observing sensors.

## **OBJECTIVES**

In littoral regions like New York Harbor, the properties of the water column are spatially and temporally dynamic. Any realistic picture of this environment must take into account this variability. During the year under report, the objective was to initiate the development of an observing and forecasting system for use in New York Harbor that could be used to support both safe navigation and port security. The system is structured to enable real-time and ongoing changes to the sampling scheme of the observation system, based on model forecasts and/or user intervention.

## **APPROACH**

Effective protection against, and response to, the range of potential threats to commercial and USN vessels and waterfront infrastructure requires comprehensive knowledge of the maritime environment. This includes information regarding water and atmospheric conditions as well as vessel traffic. The challenge of providing this information is particularly difficult in shallow coastal areas and estuaries, where oceanographic and atmospheric conditions exhibit high spatial and temporal variability due to the influences of e.g., freshwater inflow, tides, micro-climate, and bottom and land topography. The design and installation of observing systems in these environments is further complicated by the presence of high turbidity, strong stratification, strong tidal and wind-driven flows, fog, and (in urban harbor areas) vessel traffic and limited shoreline access.

Sustained accurate and efficient oceanographic field measurements and forecasts are now feasible because of modern instrumentation and advanced three dimensional circulation models in which considerable confidence has been established. A carefully constructed observing and predicting system can produce nowcasts, forecasts and data-driven simulations by melding dynamics and observations via the assimilation of measurements into numerical models. The prediction systems provide

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mechanisms for important feedbacks including adaptive sampling for the observational component and improved dynamics for the model component. The New York Harbor observing system and the modeling system therefore represent mutually dependent processes. The model forecasts guide the deployment and operation of the sensors, and the data acquired from the sensors assist and enhance the model forecasts.

Real-time oceanographic information within the Harbor is obtained using various sensors placed at strategic locations to monitor the current state of the estuarine environment. The sensors include:

- 6 shore-based salinity, temperature, turbidity, and pressure sensors
- 2 moored platforms containing salinity, temperature, turbidity, and pressure sensors
- 2 Acoustic Doppler Current Profilers (ADCPs)
- a CODAR High Frequency Surface Wave RADAR system for the broad-area measurement of surface currents and waves
- Commuter ferry-based conductivity and temperature sensors

The modeling component is centered on the use of a high resolution application of the Princeton Ocean Model (Blumberg and Mellor, 1987). Water surface elevation and three-dimensional fields of currents, temperature, salinity, and water turbulence are calculated in response to meteorological conditions, freshwater inflows, tides, and temperature and salinity at the open boundaries. The model has a long history of successful U.S. Navy use and confidence in its capabilities has been established. The modeling system will provide accurate and comprehensive simulations of meteorological and oceanographic conditions in the past (hindcasts), present (nowcasts) and future (forecasts). The simulations are to be performed and archived on the Stevens Hydrodynamic Computational Laboratory's high-performance computer cluster resident in the Davidson Laboratory.

## **WORK COMPLETED**

Development of the observing and prediction system is well underway. The work completed includes:

### **Observing System –**

The sensors mentioned previously are being deployed at the locations shown in Figure 1. Several are transmitting data via secure wireless networks already. The CODAR placement at the U.S. Coast Guard facility at Norton's Point (Coney Island) has been approved. A CTD sensor has already been deployed on a New York Waterway commuter ferry, allowing near-synoptic measurement of near-surface salinity and temperature within a large area of the Harbor. These data are being transmitted to Stevens using a ferry-based wireless communication system. Data QA/QC procedures are being finalized and software for the graphical display of data is being readied.

### **Prediction System –**

To simulate the patterns of water movement in the New York Harbor region, a grid to incorporate the entire system, the Hudson River, the East River, New York Harbor, Raritan Bay, Long Island Sound and the New York Bight in a contiguous fashion is being finalized. We are employing variably sized model grid boxes that have very high resolution in the Harbor region. Data assimilation is based on inserting hourly, two dimensional fields of sea surface salinity and temperature provided by the observing system. Automatic scripts have been developed to input data from NOAA's ETA 12km

meteorological forecast model. The operational system will automatically set the duration of hindcast and forecast simulation periods and software is being written to extract and write the model forecast products. The software script and associated graphical programs are being designed to be executable by anyone in the project group.

## **RESULTS**

Based on the sensors of the observing system, a data rate of approximately one Gigabyte per year is anticipated. A Linux-based PC, running mysql database server, is used for data storage. The ferry data are sampled and transmitted every half minute via a cellular connection; they are then retrieved into the databases every hour using a Perl script. The shore-based CTD's data are sampled every 10 min and are transmitted on an hourly basis via a 487 MHz and 900 MHz series radio link. Our web server, again a Linux-based PC, queries the database so that the data, as well as by-products such as graphs, will be available on the Internet. Figure 2 shows an example of graphs illustrating the time and space variability of temperature and salinity along one ferry route. Run 1 corresponds to a 5 min morning leg and run 2 to a 5 min evening leg. Ferry travel paths are also shown in Figure 2, offering a clear indication of the enormous potential of the eventual ferry-based measuring system.

Salinity and temperature data are also available on an interactive map showing, in real-time (update every 30 sec), the ferry's position using a GPS tracking system. Both the plot and map use raw data which have not yet been quality controlled. In order to insure the real-time quality of the newly collected data, we test our data for quality control using the NDBC man-machine mix data control protocols. These protocols concern in particular data associated with physical processes, such as sea level, water temperature, conductivity and salinity. They focus on transmission errors, gross range and time-continuity checks and wind gust to wind speed checks, following Gilhousen (1998). We test our data for quality control using protocols based on static as well as dynamic checks as proposed by Miller et. al. (2003). To-date, we have focused on the spatial and temporal data structure resulting from the operational mode of the instrumented ferries. Assuming the physical data is temporally constant within a one hour time frame, the prediction system model grid is "filled out" using simple linear interpolation in two dimensions. The modified data persistence analysis can then be used as background for horizontal consistency checks. Results of the two approaches are being compared in terms of detection percentage and false alarm percent. Adapted algorithms for data quality control will be derived from these results.

The high resolution orthogonal curvilinear grid for the New York Harbor area is being finalized now. A low resolution model of the study area is being readied for preliminary forecasts. Automatic scripts based on our experience in the Northern Gulf of Mexico are set up for hindcasts and forecasts that are produced twice daily, at 0000 and 1200 hours. The system is scheduled to run for 72 hours, 24 hours in a hindcast mode and then 48 hours in a forecast mode. These simulation periods may vary depending on the availability and duration of input data from the meteorological forecast model.

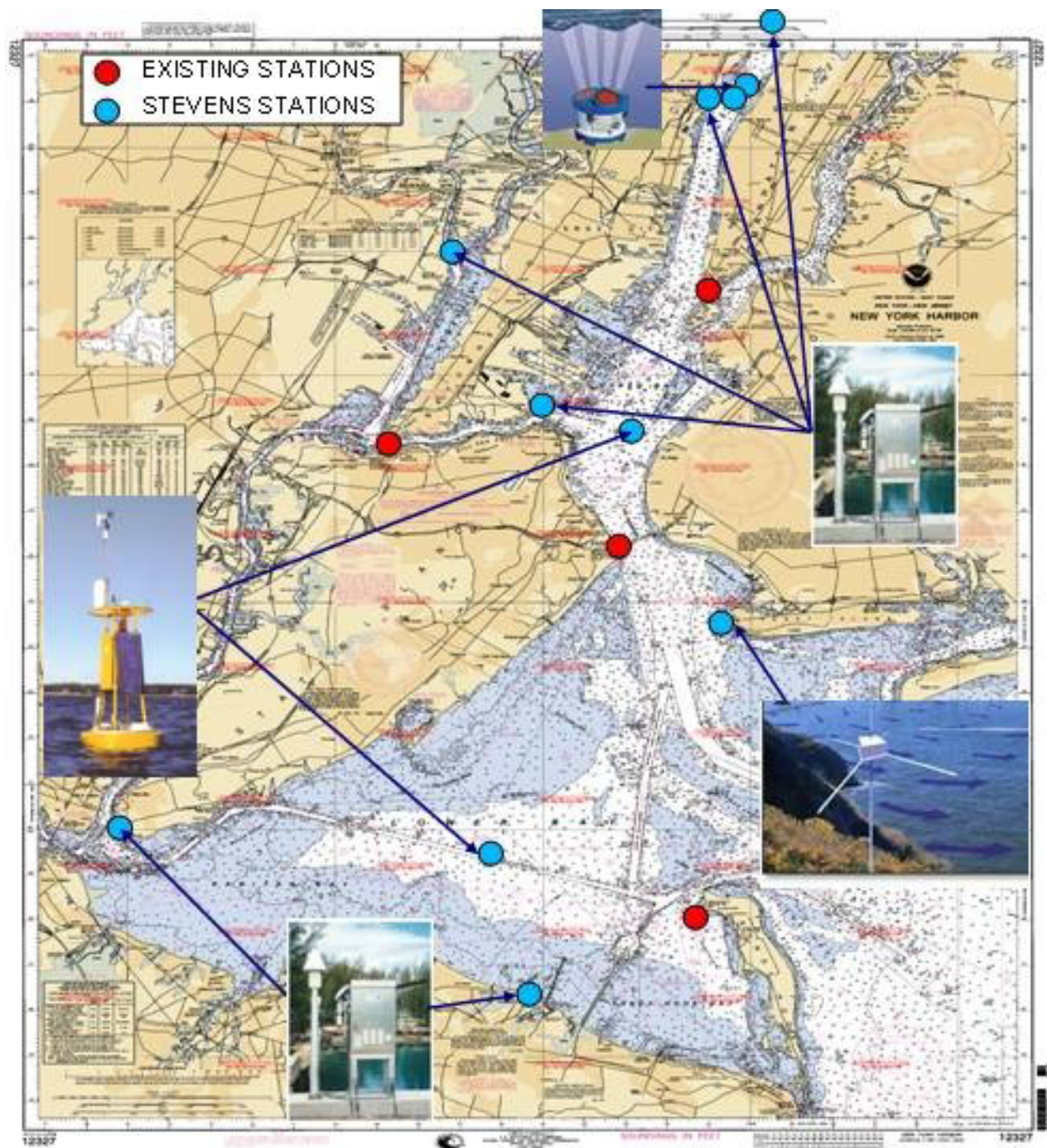
## **IMPACT/APPLICATIONS**

The work presented here provides a major step forward to coupling real-time observations with a modeling system to accurately describe the spatial fields of water surface elevations, salinity, temperature, and currents throughout New York Harbor. This will provide an accurate "situation awareness" for important applications in support of the maritime community (e.g., safe navigation and

environmental protection). It is an important goal of this program to ensure high-volume data availability and provide academic and industrial communities rapid access to high quality information.

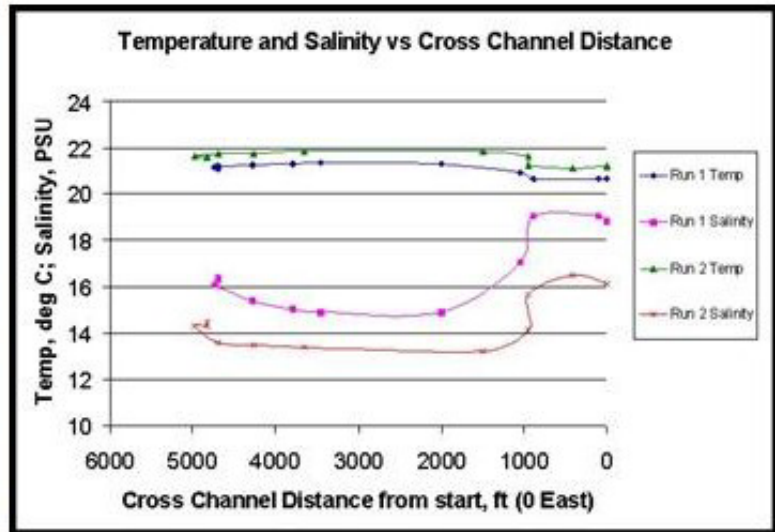
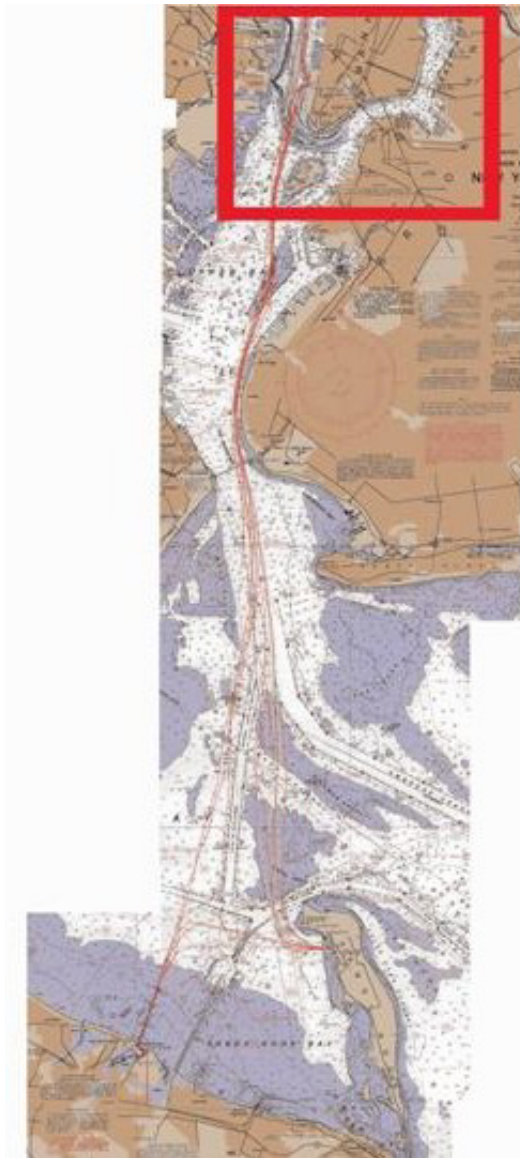
## RELATED PROJECTS

None



**Figure 1.**  
*Location of sensors included in NYHOPS*  
*Red circles indicate existing stations; blue circles indicate Stevens stations*





**Figure 2.**  
*Ferry travel paths for August 11, 2003 and surface temperature and salinity along those paths*

## REFERENCES

- Blumberg, A. F., and G. L. Mellor, 1987: A description of a three-dimensional coastal ocean circulation model. *Three Dimensional Coastal Models*, Coastal and Estuarine Sciences, 4, N. S. Heaps (ed.), Amer. Geophys. Union Geophysical Monograph Board, 1-16.
- Gilhousen, D.B, 1998: Improved Real-time Quality Control of NDBC Measurements. 10th Symposium on Meteorological Observations and Instrumentation, 11-16 January, Phoenix, AZ, American Meteorological Society, Boston. MA.

Miller, P.A., M.F. Barth, and A.E. MacDonald, 2003: Ingest, integration, quality control, and distribution of observations from state transportation departments using MADIS. 19th Int. Conf. on Interactive Information Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, Long Beach, CA, Amer. Meteor. Soc., CD-ROM, 10.11.

## **PUBLICATIONS**

“Wave Breaking and Ocean Surface Layer Thermal Response,” G. L. Mellor and A. F. Blumberg. *J. Phys. Oceanogr.*, 2003 (in press, referred).

“Mixing in the Hudson Estuary: The Role of Estuarine Circulation and Tidal Trapping,” F. L. Hellweger, A. F. Blumberg, P. Schlosser, and D. T. Ho. *Estuaries*, 2003 (in press, referred).

“Donald W. Pritchard Award,” A. F. Blumberg, A.F., 2002. *Estuarine Research Federation Newsletter*, 28, 1 & 14, 2002 (published, referred).

## **HONORS/AWARDS/PRIZES**

Michael S. Bruno appointed as a committee member of the US Department of Defense, Defense Science Board Summer Study on DOD’s Roles and Mission in Homeland Security.

Alan F. Blumberg selected to present the “Donald W. Pritchard Award,” at the 2003 Estuarine Research Federation Conference, Seattle, WA.